

Jubilee Editorial

The history of coronary care units

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Coronary heart disease excited little interest among cardiologists in the 1950s. In 1959 only six out of 65 articles in the *British Heart Journal* were on coronary disease and in 1964 seven of 89 articles were on ischaemic heart disease and 28 on congenital heart disease. There were, however, those who were concerned about how little we then knew about myocardial infarction, among them Professor (now Sir John) McMichael, who initiated research in this field at Hammersmith Hospital, and Gunnar Biörck of Stockholm who wrote: "There are few diseases in the sphere of internal medicine where the average mortality during four to six weeks hospitalization is over 30%, and if the patients with shock are particularly considered, the figure is more than twice as large. It is obvious that the task of treatment and prevention is tremendous and it appears necessary that more energy be directed to a considerable reduction in these figures. The mere quantity of the problem may have prevented us from calling all forces to arms in the 'infarct battle'. However, our surgical colleagues would never accept a mortality of this magnitude and would certainly mobilize personnel and technique to bring such figures down."¹

In fact, important advances had been taking place, although their relevance to patients with acute coronary heart attacks were not initially appreciated. Beck and colleagues in 1947 had resuscitated, by electric shock, a 14 year old boy in whom ventricular fibrillation developed during operation²; nine years later, Beck's group was successful in correcting ventricular fibrillation, using open thoracotomy, in a 65 year old physician with a myocardial infarction.³ This led them to write, with remarkable foresight, "This one experience indicates that resuscitation from a fatal heart attack is not impossible and might

be applied to those who die in the hospital and perhaps to those who die outside the hospital."³ They concluded "The veil of mystery is being lifted from heart conditions, and the dead are being brought back to life." Many surgeons then became trained in the techniques of open chest cardiac massage, but cardiac resuscitation was not taught or discussed by physicians. In the next five years about 20 cases of resuscitation after myocardial infarction were reported.

These reports of the successful treatment of "sudden death" stimulated interest at the Royal Infirmary, Edinburgh, and we decided to treat cardiac arrest complicating myocardial infarction by thoracotomy, open chest massage, and defibrillation if the circumstances were propitious. On 5 May 1960, a 40 year old physician with a myocardial infarction collapsed on admission to the ward. A scalpel, which was poised to incise a cubital fossa in an adjacent catheterisation laboratory, was diverted to initiate a thoracotomy. After some minutes, help became available from our surgical colleagues, who performed more effective cardiac massage until internal defibrillation could be carried out. The patient made an excellent cardiac recovery (he sustained some cerebral damage but survived for 23 years). By a curious quirk of fate he was an alumnus of Johns Hopkins Hospital, and shortly after his recovery he showed us an article in the hospital journal describing closed chest cardiopulmonary resuscitation, which had been developed there by Kouwenhoven, Jude, and Knickerbocker.⁴ We had by this time resuscitated (temporarily) two other patients by open chest techniques, and we used closed chest massage for a further two patients in that year. Although they both died later, it was apparent that our inability to keep more than one of our five patients alive was due to the delay in initiating treatment and lack of skills in the staff at hand. It, therefore, seemed appropriate to write:

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"Many cases of cardiac arrest associated with acute myocardial ischaemia could be treated successfully if all medical, nursing, and auxiliary staff were trained in closed-chest cardiac massage and if the cardiac rhythm of patients with acute myocardial infarction were monitored by an electrocardiogram linked to an alarm system." ... "All wards admitting patients with acute myocardial infarction should have a system capable of sounding an alarm at the onset of an important rhythm change and of recording the rhythm automatically on an ECG." ... "The provision of the appropriate apparatus would not be prohibitively expensive if these patients were admitted to special intensive-care units. Such units should be staffed by suitably experienced people throughout the 24 hours."⁵

This first description of what later became known as the coronary care unit was presented to the British Thoracic Society in July 1961, and published in the *Lancet* shortly afterwards.⁵ When these concepts were proposed to the medical staff of Sydney Hospital (notably Dr Malcolm Whyte and Dr Gaston Bauer) they were welcomed enthusiastically and plans were put in hand in October 1961 to provide the necessary beds, apparatus, and staff training. Monitoring of patients with myocardial infarction started early in 1962 and became routine in Sydney Hospital later in that year. Virtually simultaneously, Day in Kansas, Meltzer in Philadelphia, and Brown in Toronto started similar units. In 1963, units were opened in Melbourne by Sloman, in New York by Grace, and in Miami by Ungar, but few others started in the next year. The picture changed dramatically, particularly in North America, after the publication of the first reports by Day⁶ and Brown *et al.*⁷ The first report from Sydney was rejected by the *Lancet*, because the journal had recently accepted Brown *et al.*'s article, and by the *British Medical Journal* because "it was irresponsible to suggest that all patients with acute myocardial infarction should be admitted to wards in which they can receive intensive care." It was published nine months later in the *Medical Journal of Australia*.⁸

The first presentation of coronary care given to the British Cardiac Society was at the Autumn meeting in 1964 when the Sydney experience was described. At the same meeting Shillingford and his colleagues reported the setting up of a special unit at Hammersmith Hospital for the intensive investigation of myocardial infarction.

Meltzer and Kitchell, in a historical review of coronary care units, described five phases in their development: the resuscitation phase, the phase of vigorous management of arrhythmias, the phase of the vigorous investigation and treatment of pump failure, the phase of out of hospital coronary care,

and a final phase aimed at the prevention of sudden death.⁹ To this, Norris has added a sixth phase—that of trials for restriction of infarct size.¹⁰

The phase of resuscitation

It was essentially the successes of closed chest cardiac resuscitation that triggered the creation of what Day christened the coronary care unit. Initial results of treating ventricular fibrillation were not good, but rapidly improved as more staff were trained. Thus in Sydney only one of the first nine patients survived compared with six of the next 15.¹¹ A crucial advance, not only in coronary care but in hospital medicine generally, was giving nurses the responsibility for the detection and treatment of arrhythmias (including defibrillation). Meltzer and Kitchell in Philadelphia, who were responsible for this development, writing about their early experience said "Informal attempts were made to monitor selected patients (using makeshift equipment) by having a rotating team of house officers remain in constant attendance in the unit. The results were dismal: the resident physicians were hopelessly bored with the inactivity and the seemingly endless vigil, and it became necessary to discontinue the effort abruptly to avoid (what now would be called) a demonstration. By default, a system of specialized care was then conceived wherein nurses rather than physicians assumed the primary responsibility for surveillance as well as for emergency treatment."⁹

By the late 1960s all units were reporting excellent results in cases of primary ventricular fibrillation but a low success rate in those in whom this arrhythmia had been preceded by shock or cardiac failure. In the 20 years since then the situation has remained much the same.

The attack on arrhythmias

Curiously, although the first four coronary care units used similar methods of monitoring they came to rather different conclusions about the major mechanism of death. Day found that asystole was the commonest arrhythmic problem (eight of 11 cardiac arrests)⁶ and Brown *et al* reported that ventricular fibrillation was relatively uncommon⁷; whereas in Philadelphia¹² and Sydney¹¹ ventricular fibrillation was considered to be the greatest single cause of death. These differences probably reflected the different types of patient admitted to the four units. Eventually, the results of these and other units proved similar, with ventricular fibrillation being seen in 8–10% of patients.

Workers in the earliest coronary care units had all been intensely interested in arrhythmias and con-

duction disorders and it had soon become apparent that arrhythmias were much more common than had previously been suspected.¹¹ Particular attention was paid to ventricular extrasystoles because they were found to be almost universal. This interest culminated in the classic paper by Lown's group which reported that not one of 300 patients with myocardial infarction developed ventricular fibrillation.¹³ They attributed this remarkable result to the detection of "warning" arrhythmias and their treatment with lignocaine.

After this report there was a tremendous enthusiasm for the detection of arrhythmias and in many units nurses were instructed to intervene at the first sign of "ectopy". Increasingly they were expected to identify even the most rare arrhythmias and to become experts in fascicular blocks. Not surprisingly, scepticism eventually crept in, with Lie *et al*¹⁴ in Amsterdam and El-Sherif and his colleagues¹⁵ in Miami actually having the temerity to doubt the existence of "warning arrhythmias". It has now become fairly clear that there is a relation, albeit rather weak, between the R-on-T phenomenon and primary ventricular fibrillation, but the other ventricular arrhythmias including ventricular tachycardia are about as common in those who do not develop primary ventricular fibrillation as in those who do.¹⁶ The relation between warning arrhythmias and secondary ventricular fibrillation has never been satisfactorily studied.

The development of coronary care coincided with a rapid expansion in the use of transvenous pacing. As with ventricular arrhythmias, indications for treatment were progressively widened so that in 1967 transvenous pacing electrodes were inserted in 35% of patients with myocardial infarctions in the New York Hospital-Cornell Medical Center.⁹ Subsequently, the relatively benign course of sinus bradycardia and of heart block in inferior myocardial infarction became clearer and electrodes are now much less frequently used than they were.

The attack on pump failure

With the successes in resuscitation and the ability to control arrhythmias and conduction disorders the main causes of death became advanced left ventricular failure and cardiogenic shock. Before the introduction of coronary care units there had been few studies of the cardiorespiratory consequences of myocardial infarction, partly perhaps because of the expected risks of invasive investigation. By the time of the first international meeting on coronary care, held in Edinburgh in 1967,¹⁷ a large amount of information had been gathered, notably by Malmcrona and Varnauskas in Sweden,¹⁸ by Shillingford's

group at Hammersmith,¹⁹ by Mackenzie²⁰ in Donald's group in Edinburgh, and by Nixon at Charing Cross Hospital.²¹ Shortly afterwards the Myocardial Infarction Research Units (MIRU) were created in the United States and a large programme of research was initiated into the investigation of the haemodynamic effects of myocardial infarction. It had been shown that the commonly used right atrial and "central venous" pressures provided an unreliable index of left sided function²²; the introduction of the Swan-Ganz²³ flow guided catheter was a major advance in the evaluation of cardiac performance in the coronary care unit. This allowed the more precise delineation of the various haemodynamic subsets of patients²⁴ with myocardial infarction and facilitated their more rational treatment.

Enthusiasm for invasive monitoring has varied enormously from one centre to another. In many hospitals, notably in the United States and Australia, invasive monitoring became virtually routine while in the United Kingdom only a few hospitals have had the facilities and expertise to use it. At present it is probably true to say that it is used in a small proportion of cases (perhaps 5–15%) even in those institutions that have access to invasive monitoring. Its use is largely dictated by clinical indications. These are essentially cardiogenic shock and severe left ventricular failure, and few would question the advisability of having precise measurements of left and right-sided pressures when potent inotropic and vasodilator drugs are being used. The cost of the resources and drugs used in complicated myocardial infarction is considerable and it is unfortunate that we still have no well controlled studies of the value of such investigations and the effect of such treatments.

Prehospital coronary care

The introduction by Pantridge and his colleagues of prehospital coronary care in 1966 was an advance of the greatest importance.²⁵ Prehospital care was also developed in the Soviet Union but the concepts were quite different from those of Pantridge—the primary concern was with the treatment of cardiac failure and shock rather than the prevention and treatment of cardiac arrest. In 1968 Chazov wrote: "Fibrinolytic therapy (streptokinase) is started within the first hours after the onset of the disease. The treatment is derived from the fact that thrombosis of the coronary arteries is revealed in 70–80% of myocardial infarction cases. When started early and carried out for a sufficiently long time ... this therapy leads to marked improvement in the course of myocardial infarction—rapid control of pain, less

cardiac failure, less rise of blood transaminase, and more rapid signs of ECG healing. The effect of the therapy is associated with the action of the preparations on the principal thrombus, but also with the spasmolytic properties of heparin and fibrinolytic enzymes. In addition, the effect on the so-called secondary thrombi is of great significance in reducing the area of ischaemia and necrosis.²⁶

Because Geddes recently reviewed the 20 year history of prehospital coronary care²⁷ I will not consider this aspect further. It has taken all of these 20 years to achieve acceptance, at least in the United Kingdom, but at last it seems that there is general enthusiasm for prehospital coronary care and the Department of Health and Social Security is encouraging the extended training of ambulancemen. Paradoxically, whereas the realisation that techniques of coronary care can be practised by paramedical personnel finally led to this change of approach, a reversion to Pantridge's original approach of using doctors for prehospital care will probably follow the introduction of thrombolytic treatment.

Limitation of infarct size

The idea that early intervention might limit the eventual extent of infarction was implicit in Pantridge's development of the mobile coronary care unit²⁸ and made explicit by Chazov,²⁶ but the concept of limitation of infarct size also owes much to the work of Maroko and Braunwald.²⁹ More than 30 forms of treatment have been tried out in animals or man with this aim in view; so far only β blockers^{30 31} and thrombolytic agents^{32 33} appear to have stood the tests of time and clinical trials. Convincing evidence of the value of these treatments has only been forthcoming recently and it is too soon to know how widely they will be used and what their impact will be on coronary care. Thrombolytic treatment must be started as early as possible; however, admission of coronary patients to intensive care is still deplorably slow. In the late 1960s and early 1970s the median time from the onset of symptoms to admission to coronary care units was usually 5–6 hours; it is probably no better now except where prehospital schemes are in force. Indeed, there are teaching hospitals where the median admission times are in excess of eight hours. It is clear that there must be major initiatives inside and outside hospital to accelerate the care of patients with acute myocardial infarction.

The effectiveness of coronary care units

If the British were rather slow in implementing

coronary care, they were not backward in questioning its value. Cochrane in 1972 wrote that "the battle for coronary care is just beginning."³⁴ Rose was particularly critical of the early units for not more carefully comparing their experiences before and after the introduction of coronary care and he also suggested that if intensive coronary care were indeed effective there should have been some impact on national mortality figures.³⁵

In fact, in Edinburgh an administrator with a special expertise in epidemiology was asked to advise on the assessment of the effect of the opening of the unit, and a research fellow was appointed to undertake this. During the first year of operation of the unit mortality was 16.4%, compared with 23.4% in an apparently comparable group of cases in the preceding year.³⁶ Ninety one (15%) of the first 600 patients died; however, a further 25 (4%) of the patients became long term survivors of ventricular fibrillation. The mortality had, therefore, been reduced by 21% by this means alone. Others who compared mortality in the general wards with that of the coronary care unit included Meltzer,³⁷ Hofvendahl,³⁸ and Brown and MacMillan³⁹; all reported a substantially lower mortality in the coronary care unit.

Another approach to the assessment of the potential of coronary care was the setting up of the Edinburgh Community Study,⁴⁰ which sought to determine the number of heart attacks in the community and their management. It became apparent that even such a study could not accurately assess the impact of coronary care on the community, although it confirmed the high incidence of early deaths that could not be affected by conventional coronary care. A clear cut immediate effect on the number of coronary deaths in Edinburgh was not expected because these had been increasing in the preceding years. In the United States, Australia, and New Zealand, however, where the institution of coronary care has been most extensively promoted, the mortality of those between the ages of 35–64 has been falling since 1967⁴¹ (the time of the widespread introduction of coronary care units). It is clearly wrong to attribute most of the fall in mortality rates in the countries cited to the introduction of coronary care units; Reader suggested that it might be responsible for at least 20% of this reduction.

All these attempts to assess the effectiveness of coronary care units were unquestionably of dubious validity. In 1967 Oliver and his colleagues, who already had had extensive experience of clinical trials, pointed out why it would be virtually impossible to carry out a valid randomised control trial of coronary care units.⁴² None the less, trials of home versus hospital treatment were mounted in Bristol and

south west England,⁴³ and in Nottingham.⁴⁴ Essentially, both studies found that there was little or no benefit from hospital treatment. These results have been extensively debated since and this is not the place to repeat the arguments. In any case, our knowledge of how to conduct clinical trials has increased enormously since then. In particular, we have learned of the importance of ensuring that the study has sufficient power before concluding that a treatment is ineffective. Furthermore, we must be sure that the treatment (whether we are using drugs, surgical treatment, or resuscitation techniques) is being competently applied to those most likely to benefit from it before we damn it. Despite their defects, these studies did serve a very important function in drawing attention to the fact that intensive care can have no significant impact on mortality in low risk groups (such as those in good condition several hours after the onset of symptoms).

The future of coronary care units

CORONARY CARE OR CARDIAC CARE?

Many of the patients admitted to coronary care units have not sustained a myocardial infarction. The units have been of inestimable value in treating patients with arrhythmias and in managing unstable angina and other cardiac emergencies. "Coronary care unit" is therefore a widely accepted misnomer; "cardiac care unit" is perhaps a more accurate term but it does not seem to have the same appeal.

SHOULD CORONARY CARE BE PART OF INTENSIVE CARE?

At one time there was the widespread feeling that coronary care units should be integrated with intensive care units. This has not happened to any great extent, although there are some successful examples. Combined units can work well provided that the cardiac beds form a distinct part and a cardiologist is responsible for the cardiological training and practices of the staff.

SHOULD CORONARY CARE UNITS BE LINKED TO CARDIAC CATHETERISATION AND CARDIAC SURGICAL FACILITIES?

The role of cardiac catheterisation, angioplasty, and cardiac surgery is increasing in the management of patients admitted to coronary care units for myocardial infarction, unstable angina, or arrhythmias. The various facilities in cardiac centres must be designed to take account of these functions.

HOW CAN THE BENEFITS OF CORONARY CARE BE MAXIMISED AND ITS COSTS MINIMISED?

Coronary care remains an expensive form of management that can only be justified if it is restricted to those patients likely to benefit from it. The most urgent need is to accelerate the initiation of coronary care, including the administration of thrombolytic treatment, outside and inside hospital. Cardiologists throughout the United Kingdom should attempt to ensure that prehospital coronary care is improved, and that the physicians in the 25% of hospitals that do not have cardiologists are made aware of the importance of implementing appropriate acute coronary management.

Simpler and cheaper methods need to be devised to monitor patients whose only major risk is ventricular fibrillation, and the effectiveness of expensive invasive monitoring and the newer forms of treatment of shock and cardiac failure needs to be evaluated in controlled trials.

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